Effect of Peripheral Shielding on Lymphoid Tissue Response to Irradiation in C 57 Black Mice[1]

Henry S. Kaplan and Mary B. Brown

Department of Radiology,
Stanford University School of Medicine,
San Francisco, California

Lymphoid tumors originating in the thymus are consistently induced with high yield by periodic systemic irradiation of strain C 57 black mice (*1*). Their development is largely inhibited by placing a lead shield over the thigh or other peripheral regions during treatment, despite the fact that the thymus receives the same x-ray dose (*2*). It has now been found that initial thymus injury is not affected, but that thymic recovery is significantly accelerated by thigh shielding. Lymph node recovery is also accelerated, though to a lesser degree.

Littermate mice of both sexes, aged 33 ± 3 days at the start of treatment, were assigned to one of two groups designated for sacrifice at serial time intervals. Four exposures of 168 r each were delivered at 8-day intervals on experimental days 1, 9, 17, and 25. Physical factors were 120 kvp, 9 ma, 0.25 mm Cu + 1.0 mm Al added filter, 30 cm mouse-target distance, 32 r/min. This dose and rhythm of treatment regularly yield a lymphoid tumor incidence of 80–95% (*3*). In one group a lead shield 3 mm thick and 1 cm wide was placed across the right thigh during each exposure; the other irradiated group was unshielded. A third group of untreated controls was established at some of the time intervals studied. There were 6–8 mice/group at each time interval. Determinations at 29 and 40 days were rechecked with additional littermates assigned to shielded and unshielded groups. On the designated experimental days the thymus, spleen, and pooled superficial lymph nodes (2 axillary, 2 inguinal) were rapidly excised, dissected free of surrounding fat and connective tissue, and weighed on a torsion balance. Portions of each tissue were taken for fixation in Bouin's fluid and subsequent histologic examination; the remaining portions were used for nucleic acid studies to be reported later.

The weights of thymus and pooled lymph nodes are summarized in Figs. 1 and 2. Reduction in weight occurred after each irradiation, with partial recovery between successive exposures. Initial response was almost identical in the shielded and unshielded groups. Within 4 days after the last treatment, however, mean thymic weights were significantly greater ($P = < .001$) in the shielded mice than in their unshielded littermates. Thymic weight recovered rapidly thereafter in the shielded animals, overshooting control levels at 55 days and settling slowly back to normal afterward. Thymic weight in the unshielded animals did not fully recover until 85–100 days. A similar delayed recovery

[1] This investigation was supported by a grant-in-aid from the National Cancer Institute, National Institutes of Health, U. S. Public Health Service.

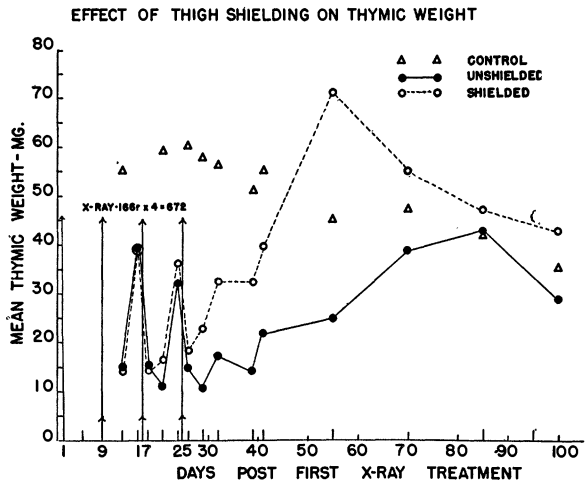

FIG. 1. Effect of peripheral shielding on lymphoid tissue response to irradiation in C 57 black mice.

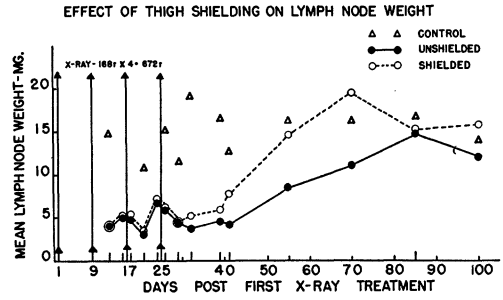

FIG. 2. Effect of thigh shielding on lymph node weight.

occurred in lymph nodes, but acceleration of recovery by shielding was less striking. Recovery of spleen weights occurred promptly in both irradiated groups.

Histologic examination revealed an initial profound reduction in lymphocytes, with "reversal" of relative cellularity of thymic cortex and medulla in both irradiated groups (*4*). Proliferation of lymphocytes with partial re-establishment of the cortex had occurred by day 29 in the shielded animals, and morphologically normal though small thymus glands were seen by 32 days. Similar stages of histologic repair were delayed by several days in the unshielded animals. Differences in the rapidity of histologic recovery were suggestive in lymph nodes also, but were of lesser degree. Proliferation of erythropoietic and myelopoietic elements in the red splenic pulp was seen in most instances at 29 days and probably accounts for the rapidity with which the spleen regained normal size and weight in both irradiated groups.

It seems reasonable to suppose that the effects of thigh shielding on thymic recovery and on inhibition of thymic lymphomas are related phenomena. On this assumption, it appears that the severity of the initial thymic radiation injury is less significant than the length of time required for recovery as an index of the probability of subsequent lymphoid tumor development. A possible clue to the mechanism by which thigh shielding acts is afforded by the recently re-

ported protective effect of injected bone marrow suspensions against acute radiation mortality (*5*). Whether bone marrow suspensions release a humoral agent, as has been postulated in the case of spleen shielding (*6*), or simply provide colonies of undamaged cells for repopulation of irradiated hemapoietic tissues, remains to be established.

References

1. KAPLAN, H. S. *J. Natl. Cancer Inst.*, **11**, 83 (1950).
2. KAPLAN, H. S., and BROWN, M. B. *Ibid.*, **12**, 427 (1951).
3. ———. *Cancer Research*, **11**, 262 (1951).
4. MURRAY, R. G. In William Bloom (Ed.), *Histopathology of Irradiation from External and Internal Sources*. New York: McGraw-Hill (1948).
5. LORENZ, E., *et al. J. Natl. Cancer Inst.*, **12**, 197 (1951).
6. JACOBSON, L. O., *et al. Science*, **113**, 510 (1951).

Manuscript received March 17, 1952.

An Investigation of Antimony Oxide as an Opacifier for Porcelain Enamels and Glass[1]

A. E. Pavlish[2] and L. S. O'Bannon[3]

Battelle Memorial Institute, Columbus, Ohio

Experimental work was carried out to determine the feasibility of opacifying porcelain enamels and special glasses by the precipitation of an antimony-bearing phase in the basis composition.

During the period between 1935 and 1940, antimony oxide and sodium antimonate were used extensively in the production of opaque white porcelain enamels. Since 1940, however, zirconium oxide and, even more recently, titanium oxide have practically replaced antimony oxide as the opacifying material in wet-process, sheet-steel enamels, although appreciable quantities of antimony oxide and sodium antimonate still are being used in the dry-process cast-iron enameling industry. The zirconia-bearing and titania-bearing enamels have higher opacity per unit of weight, higher gloss, and, in the case of titania enamels, high resistance to acids. In the case of the conventional antimony-bearing enamels, opacification essentially is accomplished by the physical dispersion of a finely divided antimony compound in the glass. In the case of the titania and zirconia enamels, the mechanism of opacification consists of the precipitation of the opacifying phase during the firing operation. Work was therefore carried out to determine whether glass systems might be developed which would permit the precipitation of an antimony-bearing phase in an enamel-like composition, thereby obtaining higher opacity than is possible with present compositions.

[1] The permission of the Texas Mining and Smelting Division of the National Lead Company to publish the results of this investigation, and the assistance of L. O. Upton, I. Mockrin, and C. R. Austin on various phases of the study, are gratefully acknowledged.

[2] Formerly a member of the staff of Battelle Memorial Institute; now technical director, Kelley Island Lime and Transport Company, Cleveland, Ohio.

[3] Consultant, Ceramic Research, Battelle Memorial Institute, Columbus, Ohio.

It has generally been agreed (*1, 2*) that, in dealing with recrystallization phenomena, the composition and the time-temperature relationships are important controlling factors in obtaining opacity in, for example, opal glasses. In the production of an opaque glass by recrystallization, another factor—namely, the nature of the crystalline product produced—also is of importance. The size and number of crystallites as well as their composition will influence the opacity of the glass. Blau (*1*) presented an excellent discussion of the effect of inclusions on the opacity of a glass. The opacifying compound in an antimony-bearing enamel has been described variously as antimony pentoxide (*3, 4*) or as an antimony, calcium, oxygen, and fluorine compound of high opacity (*5, 6*). Some confusion also appears to exist as to the exact identity of the compound responsible for the opacity in enamels of the zirconia or titania types (*3, 6, 7*). Opacifying compounds said to be present in the crystalline phase in enamels and opal glasses are sodium fluoride and calcium fluoride.

Kreidl and Weyl (*2*) attributed the importance of the fluoride ion to its small atomic radius and, accordingly, to the strong forces exerted on neighboring atoms. The importance of alumina as a constituent in opal glasses (*2*), in enamels (*7, 8*), and in matte glazes (*9*) has been mentioned. Another oxide generally considered to be important in enamels and opal glasses is zinc oxide. This oxide was stated to increase the rate of crystal growth in opal glasses (*2*), whereas, in zirconia enamels, its effect on opacity apparently was like that of alumina, resulting in a reduction of the solubility of zirconia (*8*). Other materials that have been held to be important in the development of opacity in antimony-bearing enamels include oxidizing agents such as sodium nitrate (*10*), potassium nitrate, or zinc nitrate; calcium compounds such as calcium fluoride (*5, 11, 12*); and sodium silicofluoride (*13*).

This paper covers the experimental results obtained during an investigation of the effect of various additions on the opacity of a high-antimony basis porcelain enamel-like glass. The composition of the glass and the additions were based on a considerable amount of laboratory work of an exploratory nature which led to these trials.

The analyzed composition of the basis enamel used in this investigation was as follows:

Oxide	Amount (%)
Na_2O	20.8
B_2O_3	12.5
SiO_2	46.6
Sb_2O_3	19.1
R_2O_3	0.7
H_2O	0.2

Various oxides or combinations of oxides were added to this composition as opacifiers. In tests in which the addition amounted to 20%, the oxides were added to the raw batch. When the additions amounted to less than 20%, however, they were added to a pre-